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Computer physician order entry and clinical decision support systems: Benefits and concerns

Joseph Shaffer
Marshall University

Alberto Coustasse
Marshall University, coustassehen@marshall.edu

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COMPUTER PHYSICIAN ORDER ENTRY AND CLINICAL DECISION SUPPORT SYSTEMS: BENEFITS AND CONCERNS

Joseph Shaffer, Marshall University
Alberto Coustasse, Marshall University

ABSTRACT

Computerized Physician Order Entry has emerged as the greatest potential to decrease medications errors and improve efficiency. A literature review was conducted in systematic stages that included the research data from the last 25 years. Efficiencies were found with a decrease in overall workload of nurses, pharmacists and clerical workers. This led to decreased operating expenses. A secure way of transferring physician orders electronically will help hospitals and physicians practice a more efficient and higher quality of care in the US healthcare system.

Keywords: Computerized Physician Order Entry, Clinical Decision Support Systems, Medication Errors, Medical Order Entry Systems

INTRODUCTION

Background

Medical errors are a major problem in the United States (U.S.) because of the overall costs to the healthcare system and their effects on quality. Between 44,000 to 98,000 citizens die each year due to medical errors and one million people are injured (Kohn and Corrigan, 2000). Despite of much debate surrounding the accuracy of mortality estimates, general agreement exists that iatrogenic injures are frequent, costly and often preventable (Barker, 1982; Bates et al., 1995; Dean, 1995; Kaushal et al., 2001). With the release of To Err is to Human starting in 1999, the Centers for Disease Control (CDC) and the Institutes of Medicine (IOM), has asserted needed awareness to medication safety (Kohn & Corrigan, 2000). Congressional leadership has thus followed with the most recent implementation of the Health Information Technology for Economic and Clinical Health (HITECH) Act by the Department of Health and Human Services (DHHS), via the Centers for Medicaid and Medicare Services (CMS), in the final rule, 45 CFR Part 170 (DHHS, 2010). Among the leading components to address medical errors is the requirement of Eligible Providers (EP) and hospitals to have electronic health records with a Computer Physician Order Entry (CPOE) component. More specifically, in the final rule, CMS will only reimburse EP's that met assessment measurers wherein 30% of all patients have at least one medication in their medication list that was entered by the EP or has been admitted to the eligible hospital or Critical Access Hospital (CAH) inpatient or emergency department with at least one medication (DHHS, 2010).

CPOE entails the physician's use of computer assistance to directly enter medical orders (e.g., medication, laboratory, or radiology) from a desktop computer or a mobile device (Ash, Berg, and Coiera, 2004). Most all systems have a basic Clinical Decision Support System (CDSS) which may include suggestions or default values for clinically based best practices such as drug doses, frequencies, or routes. More refined CDSSs can perform drug allergy checks, drug-laboratory value checks, drug-drug interaction checks, in addition to providing cues about corollary orders (e.g., prompting the user to order blood pressure checks after ordering a beta-blocker) or drug guidelines to the physician at the time of drug ordering **(**Shojania, Duncan B.W and McDonald, 2001**)**.

CPOE systems can reduce medical errors by 55 to 88% and implementation at non rural hospitals U.S. hospitals can prevent three million adverse drug events each year (Bates et al., 1998; Lwin and Shepard, 2008). By design, CPOE can eliminate illegible handwriting, avoid transcription errors, improve response time, accuracy and completeness; and improve coordination of care (Ash et al., 2004). Several outcome categories' to assess beneficial outcomes variables include; laboratory testing ordering, radiologic test ordering, medication errors, antibiotic patterns, clinical support systems and dosing appropriateness (Kuperman and Gibson, 2003).

Assessment of Capital Costs and Decision-Making for Implementation

In order for hospitals to assess costs, most often, management decisions are made based on internal documents and interviews between hospital administrators and various CPOE systems programmers and representatives. A cost analysis can include physical capital costs (workstations, printers, software, network,) operational costs over the length of implementation that includes leadership and training costs, and other costs involving the medication administrations system, pharmacy system, and clinical data repository (Barbell et al., 2010).

Concern of Providers and Hospitals for Implementation

Hospitals have to be concerned about the potential draw backs of implementing a CPOE system. Physician acceptance and behavioral changes needed are one area of major concern. Aside from those concerns, hospitals have to consider the liability risks surrounding CPOE induced errors (Mangalmurti, Murtagh, and Mello, 2010). Various problems with CPOE systems included; over alerting physicians, copying and pasting of medical information, discontinuity between information systems and poorly designed systems that fail to consider clinical changes *(Hammond, Helbig, Benson, and Brathwaite-Sketoe, 2003;* Berger and Kichak, 2004; Thielke, Hammond, and Helbig, 2007). Lastly, since the inception in 1969 of decision support platforms only seven to ten percent of medical facilities have instituted some form of CPOE system (Ford, McAlearney, and Phillips, 2008).

The purpose of this literature review was to assess CPOE and CDSS to identify areas of benefit and concern to illustrate the current condition of information technology in the U.S. health care system.

METHODOLOGY

The process conducted for this literature review followed the basic principles of a systematic search. The research hypothesis of this study was that support for and benefits of CPOE and CDSS will improve quality of care and decrease the percentage of medical errors within the US healthcare system.

Key words for search were; "computerized physician order entry" OR "CPOE" OR "clinical support systems" OR "medical order entry systems" AND "medical errors" OR "costs" OR "benefits" OR "quality" OR "medications errors." Databases that were employed included; Pub Med, EBSCO host, Department of Health and Humans Service (DHHS), the Agency for Health Care Research and Quality (AHRQ), Google and Google Scholar, the U.S. Federal Registry of Archives, and the Leapfrog Group. The total studies reviewed in detail were 295, the studies included in the final analysis, 150, and studies for the final systematic review included 46. In addition relevant books, nationally recognized reports, and pertinent website were visited, reviewed and included. The requirements of inclusion ranged from 1985 to 2011. Only articles published in English were validated. This paper excluded reviewed articles that were based on the overall value, benefit and costs of Electronic Medical or Electronic Health records to avoid broad and over lapping themes. Contradictory articles and information seemed frequent among potential benefits of CPOE thus a table was established with pertinent details of previous quantitative research done to try and compare results. The literature review was conducted by JS and validated by AC.

RESULTS

CPOE was shown, in one research comparison study of prescriptions before and after, to have the largest reductions in errors in illegibility (97%), use of inappropriate abbreviations (94%) and missing information (85%). There was also a 57% reduction in of errors in potential Adverse Drug Effects (ADE) (Devine et al., 2010).

Improvements in Efficiency with Implementation

According to a recent study in 2009, mean total time for placement of physician order to nurse receipt before implementation was 41.20 minutes per order (38.4 minutes for clerical unit transcription, 2.10 minutes finding the patient chart, 0.7 minutes for writing order) compared to 27 seconds per order after using CPOE (Stone, Smith, Shaft, Nelson and Money, 2009). In addition to decreasing the time of placement, medication turn-around time decreased significantly in one study. During one retrospective research period the number of infants receiving a loading dose of caffeine received the medication before two to three hours vs. those in the pre CPOE group (Cordero, Kuehn, Kumar, and Hagop, 2004).

Another similar study found significant savings in pharmacy-turn around with a 64% decrease in time with order entry to pharmacy, 2:20 minutes savings, and pharmacy to medication administration, 1:36 minutes savings (Mekhjian et al., 2002). Furthermore, in the radiological turn-around, from order to image display for clinical usage, time decreased overall from 42 minutes in a pre-CPOE vs. 34 minutes post-CPOE (Cordero et al., 2004). Clinical Laboratory and pathology turn-around time decreased 25%, from 31:30 minutes to 23:40 minutest in a medical intensive care unit and surgical intensive care units (Mekhjian et al., 2002).

Cost Saving with Implementation

The efficiencies saved in time can significantly attribute to savings of overall operating costs and ultimately a hospitals bottom line. One study found that the decrease workload for unit secretaries, clarifying order and transcribing them into formats for ancillary services, and eventual elimination of position as a direct result of implementation of CPOE, translated to a yearly financial benefit of $445,500 (Stone et al., 2009). Another study found that nurses spent four to six percent of their entire work time processing medication orders before CPOE. After implementation of CPOE, there was a 20 minute saving per day of time calculated to a savings of $1,960 per day, or $715,400 per year in 2002 (Taylor, Manzo, and Sinnett, 2002). The pharmacists spent 60 % of their time on paper medications processing (pre-CPOE) and saved 20 % of their time on order verification (post-CPOE). This savings of time in dollars was about 200 minutes per day, or $5,600 per day and $2,044,000 per year (Taylor, Manzo, and Sinnett, 2002).

A cost analysis of Brigham and Women's hospital (BWH) Boston, in 1992, reported approximately $3.7 million in capital costs and $600,000 to $1.1 million per year thereafter from 1993 to 2002 in operational costs for total costs of $11.8 million for CPOE. The following 11 years the CPOE system saved a total of $28.5 million given the 80% prospective reimbursement rate at BWH. This resulted in a net benefit of $16.7 million ($2.2 million annualized). The operating budget benefits totaled $21.3 million for a net cumulative present value of $9.5 million ($1.3 million annualized) (Kaushal et al., 2006)**.**

In 2003 the cost for CPOE implementation in an average hospital was 3.3 million. Depending on the bed size cost ranged from 1.4 million (less than less than 200), to 12.5 million (plus 500 beds). The average components in this study suggest that professional services make up 31% (roughly $ 1 million), core system 25% ($812,000) other hardware 21% ($680,000) software fees 14% ($455,000) additional functions 9% ($292,000); (Culler, Atherly, Thorpe, and Rask, 2005).

Responsible Handling of Alerts within Clinical Decision Support Systems

Standardization among CPOE alerts is practically no existent with alerts being dependent on hospital compliance guidelines and vendor platform capabilities (Sisj, 2006). However, finding a balanced approach to use and frequency of alerts may be a promising and a productive endeavor. The most recognized reason for overriding alerts have been alert fatigue caused by poor signal-to-noise ratio, either the alert was not serious, irrelevant or shown repeatedly (Glassman, Simon, Belperio, and Lanto, 2002). However, lack of understanding about the importance warning, technological barriers, and unnecessary workflow interruptions can thwart correct and effective handling of safety alerts (Krall and Sitting, 2002).

One study has demonstrated that tiering the level of alert warnings based on the level of clinical drug-drug interaction importance was highly effective. Whenever a physician received a level 1 hard alert, what was considered to be life-threatening, and the clinician was required either to cancel the order he or she was writing or discontinue the pre-existing drug order, 100 percent of physicians cancelled the order. Physicians that received similar alerts at the lower level priority, level 3, adhered only 34 % of the time. (Paterno et al, 2009). Similarly, another study pointed out that when alerts were classified in high-level and low level groups, high-level alerts were more often accepted than the low-level alerts (57% vs. 8% respectively). Categories of prescription warning messages with lowest to highest level of adherence to the warning included; interactions (7%), contraindications

(15%), maximum recommended single dose exceeded (46%), maximum recommended daily dose exceeded (48%), and password level warning (57%) (Nightingale, Adu, Richards, and Peters, 2000).

In addition, two supplementary study's suggested that alerts traditionally given by the pharmacy for solving prescription problems and efforts for collaboration in helping decision making decreased significantly after the implementation of CPOE (Mullett, Evans, Christenson, and Dean, 2001; Bizovi et al., 2002).

Utilization of Compliance Standards with Implementation

Compliance with suggested hospital standards in the form of alert reminders, termed "corollary orders," was a benefit for several major randomized controlled trial (RCT) studies on CPOE. Specifically, benefits of compliance adherence was found in formulary and prophylactic heparin usage, ordering rates for pneumococcal and influenza vaccine, and display at time of ordering guidelines for use of Vancomycin (Shonjania et al., 1998; Teich et al., 2000; Dexter et al., 2001) (Table 1).

Table 1: Results of Studies Relevant to the Benefits, Costs and Outcomes of CPOE

Author	Year	Outcome Category	Design	Key Findings
Tierney et al.	1987	Laboratory test ordering	Randomized Control Trial	In the intervention group, physicians ordered 14% fewer tests and charges for tests were 13% lower.
Tierney et al.	1988	Laboratory test ordering	Randomized Control Trial	Charges for study tests were 8.8% lower in the intervention group.
Harpole et al.	1997	Radiological test ordering	Prospective Cohort	Cancellation rate in response to automated alert critics were very low; 3% in phase 1, 4% in phase 2; users accepted suggestions for alternatives studies more often; 38% in phase 1 and 55% in phase 2.
Overage et al.	1997	Compliance with drug monitoring and guidelines	Randomized Control Trial	Overall, compliance with guidelines was greater in the intervention group (46.3% vs. 21.9%).
Shojania et al.	1998	Compliance with drug monitoring and guidelines	Randomized Control Trial	Displaying vancomycin guidelines at time of ordering, physician wrote 32% less orders. Duration of medication ordered by intervention group was lower 36% lower.
Teich et al.	2000	Compliance with drug monitoring and guidelines	Time-Series	Increased frequency of use of hospitals H_2 choice; increased rate of ordering prophylactic heparin; decreased rates of excessive high dosing, increased appropriateness of frequency for use of ondansetron
Dexter et al.	2001	Preventive Care Measure	Randomized Control Trial	Increased ordering rates for pneumococcal and influenza vaccine, prophylactic heparin, and aspirin at discharge
Chertow et al.	2001	Clinical Support System	Time-Series	Renal dosing guidance and compliance helped decreased adverse drugs length of stay and increased appropriateness prescriptions, 16,470 interventions per year
Sanders and Miller	2001	Radiological test ordering	Time- Series	60% agreement with a clinical support system recommendations, increased usage of brain MRI without contrast

More specifically a RCT study conducted at Wishard Memorial Hospital, Indianapolis, assessed their CPOE system results for similar compliance standard adherences. They found their overall ordering rates increased, with the percentages of intervention group listed first and control groups second, as follows; pneumococcal 35.8% vs. influenza vaccination, 51.4% vs.1.0%, prophylactic heparin, 32.2% vs. 18.9% and prophylactic aspirin at discharge, 36.4% vs. 27.6% (Dexter et al, 2001).

Unintended Consequences of Implementation

One study found a 20% prevalence of physician computerized notes containing copied text in a manually reviewed set of 60 inpatient charts at the Salt Lake City VA Health Care System. Their detailed analysis found an average of one factual error introduced into the electronic record per human or computer affected copying series (Weir et al., 2009). In addition fuller access to patient health records tempted providers to rely on previously recorded histories, test results, and clinical findings, rather than on collecting new information (Hoffman and Podgurski, 2009).

DISCUSSION

With the passage of the HITECH Act of 2009, billions of dollars in the form of incentives for private providers and hospitals have been allocated to adopt electronic medical records. This offering invites needed efforts to change the way healthcare is delivered in the US. It is anticipated with these incentives and the standards for meaningful use implementation of CPOE among hospitals and private providers will increase significantly over the next 10 to fifteen years.

Further research will be required to address the needs of the rural hospital. Most articles reviewed focused on the large academic medical centers and hospitals wherein variations in resources may certainly have an effect on the way and the rate that adoption of CPOE occurs. In addition previous research has suggested that tiering of alerts has brought significant decreases in medication errors specifically drug-drug interactions. A balancing of alerts will be needed to avoid complications such as alert fatigue, error induced entry and an attitude of distain for the process. In an invited commentary Dr. Bates suggests that developing best practices in areas such as decision support specifically with alerts is a much needed and challenging endeavor (Bates, 2010).

The Leapfrog group has developed a CPOE evaluation tool that tests the operational functionality using a series of mock medication orders and test patients of which have known histories of medication errors (Kilbridge, 2006). This evaluation could be very effective, specifically with rural hospitals with “homegrown” systems, to reduce potential problems from the beginning.

CONCLUSION

With the history and developments over the past fifteen years the US government, major large business partners, and the healthcare community in general have brought the benefits of CPOE into the spotlight. Specifically with the establishment of the Leapfrog group, the standards of meaningful use by the Secretary of DHHS and the incentives offered in the HITECH Act, a secure way of transferring physician orders has been established that will help hospitals with efficiency and overall costs and allow physician to perform better quality of care.

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Joseph Shaffer, MSc
Marshall University Graduate College
Alberto Coustasse, Dr.PH, MD, MBA
Associate Professor
Lewis College of Business
Marshall University Graduate College
100 Angus E. Peyton Drive
South Charleston, WV 25303

Alberto Coustasse, DrPH, MD, MBA
Associate Professor, Lewis College of Business
Marshall University Graduate College
100 Angus E. Peyton Drive
South Charleston, WV 25303